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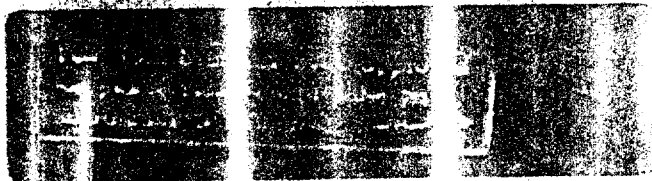
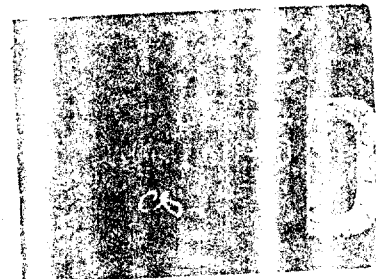
Report to the Chairman, Committee on
Foreign Affairs, House of
Representatives

August 1989

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BIGEYE ECMB

Unresolved Developmental Issues



Program Evaluation and
Methodology Division

B-211376

August 11, 1989

The Honorable Dante B. Fascell
Chairman, Committee on Foreign Affairs
House of Representatives

Dear Mr. Chairman:

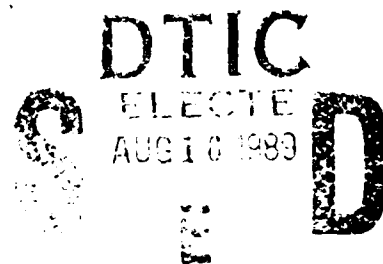
This report is an unclassified version of our report on recent developments in the Bigeye weapon program entitled Bigeye Bomb: Unresolved Developmental Issues (GAO/C-PEND-89-1). The classified report contains eight appendixes of detailed data and analysis that we are unable to discuss in this unclassified report.

The Senate Appropriations Committee report on the fiscal year 1987 Department of Defense (DOD) appropriations bill requested that DOD submit a report on four "outstanding Bigeye concerns" involving (1) problems of excessive pressure buildup, (2) the generation of lethal agent, (3) agent "flashing" (or burning), and (4) the overall reliability of the weapon. In December 1986, your staff asked us to review the DOD report when it became available and to report to you on it, as well as on other related Bigeye bomb issues.

This report analyzes the September 1987 Department of Defense report (composed of a letter and seven appendixes), which was issued in response to the fiscal year 1987 Senate Appropriations Committee requirements, as well as other relevant DOD reports and data.¹ Five of the seven appendixes in the DOD report were prepared by the U.S. Army's Chemical Research, Development, and Engineering Center (CRDEC) in Aberdeen, Maryland. A sixth, on vx flashing, was written by a former CRDEC official who is now a consultant. The seventh and final appendix, a table on Bigeye system reliability, was issued by DOD's Bigeye program office.

In preparing our analysis, we reviewed the September 1987 DOD report and CRDEC 1988 data that were included with the August 1, 1988, DOD response to a draft of our report. In addition, we analyzed findings from a June 1988 analysis of 1987 Bigeye operational field tests by the

¹The DOD report is composed of a letter from the Assistant to the Secretary of Defense (Atomic Energy) and seven appendixes to John C. Stennis, Committee on Appropriations, U.S. Senate, Washington, D.C., and is dated September 10, 1987.



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Navy's Norfolk, Virginia, operational test and evaluation force (OPTEVFOR) that are relevant to Bigeye developmental problems.²

We also interviewed DOD officials involved in the Bigeye program, including CRDEC personnel and officials in the Bigeye program manager's office. We utilized the expertise of outside consultants on chemical reactions to ensure that our evaluation had a sound scientific basis.

In response to a request from the DOD Inspector General, we asked a panel of four experts to help resolve the issues outstanding between DOD and GAO—which are discussed in the present report—concerning the test and evaluation of the Bigeye bomb. The experts were Dr. John Ahearne, Vice President, Resources for the Future; Dr. John Gibbons, Director, Office of Technology Assessment, U.S. Congress; Dr. Joseph Navarro, former DOD Deputy Undersecretary (Test and Evaluation) in the office of the Undersecretary of Defense, Research and Engineering; and Admiral Ernest R. Seymour (ret.), former commander of Navy Air Systems (NAVAIR). In addition to reading our reports on Bigeye issues, the panel was briefed by DOD on January 30, 1989, with regard to DOD's response to the draft of this report and subsequently reported their findings and conclusions to the Comptroller General.³

The panel's findings were summarized in a March 30, 1989, memorandum that was sent from the Comptroller General to the Secretary of Defense.⁴ The panelists concluded that we were correct in our evaluation that major developmental issues affecting the Bigeye remain unresolved and that further developmental tests are therefore required to answer questions that critically affect the bomb's performance.

We delayed this report so that the Congress could have the benefit of the panel's judgment, along with our own findings. Our analyses of developmental issues in each of the four relevant areas are summarized in the next four sections of this letter. In a fifth section, we discuss our analysis of lethal-agent presistency.

²Commander of Operational Test and Evaluation Force, "Multiservice Operational Evaluation of the Bigeye BLU-80/B Weapon" (Norfolk, Virginia: June 24, 1988).

³Our previous reports on Bigeye issues are Bigeye Bomb: An Evaluation of DOD's Chemical and Developmental Tests, GAO/C-PEMD-86-1BR (May 1986) and Bigeye Bomb: 1988 Status Report, GAO/PEMD-88-26 (May 1988).

⁴Letter from GAO Comptroller General to Secretary of Defense Richard B. Cheney, dated March 31, 1989.

Pressure Buildup

CRDEC conducted one additional test (designated LB-44) to determine pressure buildup in an unvented bomb with a high initiation temperature (140°F), as required by the Congress. On the basis of this one additional test, DOD concluded that pressure buildup is not likely to be a problem for the Bigeye.

However, a sample of one additional test is clearly insufficient to determine whether the results provide a reliable estimate of the true-but-unknown success rate for the universe of pressure tests. Standard statistical formulas show that five tests, all of which must be successful, are required to assure that there is a 50-percent chance that the success rate from the universe of tests with a pass-fail criterion would fall somewhere between 80 and 100 percent.

DOD officials stated at the final (exit) conference on this report that the one additional pressure test may not be sufficient to reach a sound conclusion about the susceptibility of Bigeye to excessive pressure buildup that could destroy or disable the weapon.

We conclude that DOD did not respond adequately to the congressional concern about excessive pressure buildup inside the bomb and that the issue of pressure buildup remains unresolved.

Purity and Lethality

Change in Bigeye TEMP Requirements

In its September 1987 report, DOD provided no explanation (although required to do so by the Senate Appropriations Committee) of why it changed the requirement concerning the number of seconds required to generate binary VX (the lethal agent formed inside the Bigeye bomb) at the purity or equivalent-biototoxicity level required by the Test and Evaluation Master Plan (TEMP).²

The second (January 1987) Bigeye TEMP stated that VX at the TEMP-required level need be generated only "at any time" (that is, at some instant) during the 5 through 30-second period after mixing starts, without specifying either when the required purity or equivalent biototoxicity level should be reached or for how long. The first (May 1985) Bigeye

²VX is O,S ethyl diisopropylaminoethyl methyl phosphonothioate, a persistent nerve agent. Biototoxicity is a method of measuring the lethality of the generated agent.

TEMP did not contain the "at any time" phrase. DOD states that "at any time" is a clarification of the meaning of the first TEMP rather than a revision of the purity or equivalent biotoxicity requirement.

However, we believe that a bomb that produces lethal agent at the required purity level for 1 second (or even less) may not be as effective a weapon as one that does so for 25 seconds. Furthermore, it is important to know when the 1-second-of-adequately-pure-agent will be produced so that the pilot can release the bomb at the appropriate time. Unfortunately, it is not known when the adequate purity level will occur during the mixing reaction.

DOD has apparently revised the purity criterion in another respect, since it now states that the VX requirement is for a purity or equivalent-biotoxicity level that is different from the one specified by the TEMP. We find that this is an incorrect understanding by DOD of the TEMP requirement and is not justified. DOD disagrees with our views on this issue, but further details cannot be discussed because the exact figures are classified. (See appendix IV of the classified version of this report.)

Results of Lethal-Agent Generation Tests

We differ with DOD on the number of lethal-agent generation tests conducted by CRDEC in which VX at the TEMP-required purity or equivalent biotoxicity level was produced at some point during the required 5 through 30-second period. DOD's evaluation of test results finds that VX of sufficient lethality was generated much more often than our evaluation indicates. DOD uses its estimate of lethal agent success as part of its calculation of weapon system reliability. (See the following sections for further discussion.)

DOD states that the evidence for its evaluation of test results is fully documentable and accurate. However, Bigeye program officials acknowledged in July 1988 that they had no definitive list of the tests used by the former program manager to arrive at an estimate. In April 1989, DOD provided us with a revised list of 13 tests that, it stated, showed that the TEMP requirement had been met. However, DOD reached that conclusion by using the incorrect VX criterion, cited previously, and by declaring test results to be "no-tests" in some cases where the purity requirement was not met.

Can Biotoxicity Be Predicted From VX Purity Using Available Data?

We question whether vx biotoxicity can be reliably predicted from vx purity, as stated in the DOD September 1987 report and in a June 1988 report on more recent tests. This is an important issue because the Bigeye program office stated in July 1988 that certain tests are successes, in terms of meeting purity equivalent-biotoxicity requirements, on the basis of predicting biotoxicity from observed vx purity that did not reach the TEMP-required vx purity criterion.

However, in January 1988, the CRDEC munitions test director questioned the reliability of the equation used in the 1987 report, stating that there were insufficient data on which to base the equation. More than 2 years ago, moreover, in our May 1986 report (GAO/C-PEMD-86-1BR) on the Bigeye program, we quoted DOD officials as stating that on the basis of the same data "the relationship between chemical purity and biotoxicity cannot be considered statistically significant." Yet, on the basis of these data, DOD concluded in the September 1987 report that the bomb will produce vx with a percutaneous biotoxicity that exceeds the TEMP requirement.

CRDEC issued a revised purity equivalent-biotoxicity equation in a June 17, 1988, report, but warned that the equation cannot be used to extrapolate beyond the data in it.⁶ Even with more data from two new 1988 tests, there are still just 14 biotoxicity data points, from six tests. Of these tests, only one had a high-temperature start of 140°F, none had start temperatures between 71°F and 129°F, none had a start temperature over 140°F, and two 0°F tests produced conflicting results.

The June 1988 OPTEVFOR analysis of Bigeye operational tests noted the "limited" number of data points on purity-biotoxicity and pointed out that of the 14 data points, only 11 were from tests using the current bomb configuration for off-station mixing. OPTEVFOR formally recommended additional tests with start temperatures in the 140-160°F range, to provide needed purity-biotoxicity data. We believe that the weight of the evidence shows that the currently available data are inadequate to make reliable predictions about the level of vx purity required to generate a given level of equivalent biotoxicity.

Conclusions: Purity-Biotoxicity Issues

We conclude that DOD has not dealt adequately with the Senate Appropriation Committee's concern about achieving adequate lethality in the Bigeye bomb. We find that DOD's view that the addition of the phrase "at any time" to the TEMP is only a clarification—not a change—in the

⁶CRDEC, "Bigeye Agent Purity and Biotoxicity Relationship," June 17, 1988.

requirement understates the importance of the modification. It does not appear to accurately reflect the implications of generating adequately pure agent for only an instant during the period from 5 to 30 seconds, in contrast to generating it throughout the 25 seconds.

Moreover, DOD now appears to have loosened the criterion in another regard by stating that it requires VX at a purity or equivalent-biototoxicity level that is different from the one in the TEMP. We find this to be an incorrect understanding of the TEMP requirement. We also concur with OPIVFOR's recommendation that additional tests be conducted to collect purity-biototoxicity data.

Flashing

In response to the Senate Appropriations Committee's requirement to provide test results on the level of resistance of VX to flashing (burning or vaporization of an agent), CRDEC contracted with a former CRDEC official to conduct an analysis and synthesis of related literature. The DOD report concludes that flashing caused either by an external spark or by autoignition is very unlikely to be a problem in Bigeye deliveries.

However, we believe this conclusion may be hasty since we think there is evidence that flashing could in fact occur through autoignition—burning or vaporization that results from the combination of a heated material and a fuel-rich oxygenated atmosphere that is not ignited by an external spark. In four of six Bigeye tests with temperature starts at or over 130°F, the temperature generated inside the bomb equaled or exceeded the VX autoignition temperature and, in the fifth, came within 3°C of it.

DOD states that the bomb's design precludes externally-ignited flashing and that the high recovery rate of simulants used in operational tests and the absence of observed flashing are evidence that neither externally-ignited nor autoignition flashing is likely to be a problem.

However, the tests cited were not designed as tests of flashing and had no instrumentation by which to record internal bomb temperatures. Moreover, some of the tests used nonreactive BIS simulant, which does not generate the heat or pressure typical of a Bigeye binary reaction.⁷

We also question the conclusions drawn on the basis of a CRDEC test of the bomb cited as important evidence against the possibility of either

⁷BIS is BIS-(2 ethyl hexyl) hydrogen phosphite. It is used as a nonreactive simulant of VX.

externally-ignited or autoignition flashing, because the test weapon was surrounded by a bonnet of inert Halon, a fire-suppressant chemical, that the DOD report states may have reduced chances for flashing. Further, the reaction generated an internal maximum temperature of only 223°C, far short of the 290°C autoignition point of VX.

Moreover, in August 1988, the munitions director of CRDEC noted that no data currently exist on the autoignition points of impure VX mixtures, which are the product of the binary reaction inside the Bigeye, and that it would therefore be a good idea to collect such data. Without this information, it is impossible to know whether the internal temperatures reached in tests of the bomb exceed autoignition points of the generated (impure) agent and, therefore, whether autoignition flashing could have occurred.

We conclude that DOD has not adequately addressed the issue of flashing and that additional data on the issue need to be developed.

System Reliability

DOD agrees with us that its September 1987 estimate of overall Bigeye system reliability was calculated improperly and that the overall reliability estimate is therefore wrong.

Another problem is DOD's assumption regarding the generation of lethal agent. We believe that a more accurate estimate of operational reliability must be based on the actual laboratory test success rate for generating VX at the required level of purity or equivalent biotoxicity. Using data from these tests, we determined that VX at the TEMP-required level was produced much less often than at the rate estimated by DOD.

We conclude, therefore, that the weapon system reliability is considerably lower than DOD's estimate.

VX Persistency

The DOD September 1987 report states that VX is very persistent, based in part on a test conducted in a chamber containing 0-percent humidity, a constant temperature of 73°F, and no wind. We do not question that VX is very persistent under these specific conditions. However, we believe that this test failed to provide operationally relevant information about the degrading effects on VX of wind, moisture, soil, and other absorbent factors.

This issue was also cited by the Air Force, which noted in an annex to the OPTEVFOR report that "more information on the effects of delivering Bigeye in visible moisture such as clouds, fog, rain, etc. is needed to assess the advisability of continuing a mission under such conditions." We concur with the Air Force's judgment that such information is essential to evaluating the effectiveness of Bigeye and must be collected.

Summary

We conclude that DOD has not adequately addressed the requirements in the fiscal year 1987 Senate Appropriations Committee report and that additional information or tests are required to answer basic developmental questions about the performance of the Bigeye bomb in areas critical to weapon performance: pressure buildup, purity, flashing, and persistency. Furthermore, estimates of overall weapon reliability must take into account both the lethality of the agent generated and the duration of that lethality.

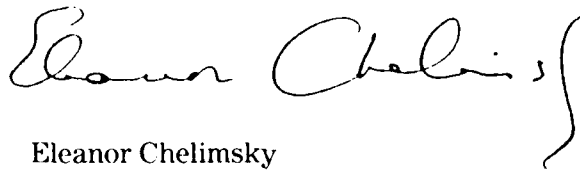
Moreover, we concur with OPTEVFOR's formal recommendation in its June 1988 report that no further operational tests be carried out until a number of steps are taken with regard to the weapon, including the following that involve developmental issues: conducting additional purity and biotoxicity tests at start temperatures from 140-160°F, researching chemical additives that would keep start temperatures under 120°F, determining the increased VX deposition levels required when agent purity is below the TEMP-required level, and improving weapon reliability. We believe that OPTEVFOR's recommendations show the need for more information on these developmental issues critical to Bigeye effectiveness, and we agree that further operational tests should be delayed until these basic developmental issues are resolved.

While this report was not provided to DOD for agency review, the classified draft upon which this report is based was provided to DOD for comment. In commenting on the classified report, DOD disagreed with most of the major concerns we raised. However, after careful review of DOD's comments and the relevant evidence, and after reconsidering the findings of the expert panel, we are confident that our concerns are well-founded. (DOD's comments and our response to them can be found in appendix VIII of the classified report.)

Our review was conducted in accordance with generally accepted government auditing standards.

If you have any questions, please call me or Carl E. Wisler, Director of Planning and Reporting, at 275-1854. Major contributors to this report are listed in appendix I.

Sincerely,

A handwritten signature in cursive script, reading "Eleanor Chelimsky". The signature is written in dark ink and is positioned above the printed name and title.

Eleanor Chelimsky
Assistant Comptroller General

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